Updates to 14CFR 64.121 - Type Ratings

In the rapidly growing market of GA, LSA, Experimental vTol and e-Vtol, the demand for aircraft mounted parachute systems has grown exponentially. In a recent survey, over 80% of the market stated they will not get into an aircraft without a parachute attached to it.

14 CFR 64.121- Type Ratings Update: With the antiquated FAA laws for Parachute Riggers, and the ever-changing parachute technology, the type ratings are in dire need of updating. Currently, the LAP rating is no longer used, nor have any parachutes been in production for this rating since World War II. The few LAP rating holders in existence are questionable as how they achieved the rating with the lack of available systems. The remaining type ratings: SEAT, BACK and CHEST, the technology has changed drastically, and the parachute rigger abilities have slacked to the point where parachute riggers are achieving ratings to meet FAA requirements, but only using a fraction of the abilities the rating provides. Proposal to update **§ 65.121 Type ratings** to read as follows:

(a) The following type ratings are issued under this subpart:

(1) Senior Rigger.

(i) Pro Pack Only.

(ii) Flat Pack Only.

(2) Master Rigger.

(i) Square Canopy.

(ii) Round Canopy.

(iii) Manned Aircraft Mounted.

(iv) Unmanned Aircraft Mounted.

(b) The holder of a senior parachute rigger certificate who qualifies for a master parachute rigger certificate is entitled to have placed on his

master parachute rigger certificate the ratings that were on his senior parachute rigger certificate.

Separating the type ratings to a more usable system where Parachute Riggers are able to use it in the industry in its current state of evolvement of technology just makes sense. This helps the end-users, like dropzones, make better judgement calls for maintenance and repairs that are needed on their equipment for day-to-day operations. Instead of needing to make a repair on a main canopy for a tandem system where a master rigger is required but not available due to not meeting all the requirements to become a current master rigger, a rigger holding the type rating for Square Canopy can make the repair the dropzone needs to get their customers in the air. That same rigger may never see/touch a round canopy system in his or her lifetime of parachute rigging on a dropzone, so why spend the time, money, effort, and energy working towards a rating they will never use? Currently riggers are receiving training for systems they will never see or touch after they are certified. It's nobody's fault, it's just the way the industry is currently operating due to the outdated current FAA laws for parachute rigger licensing. Here is why we need **(2)(iii) & (iv)** of the above proposal:

Importance of Aircraft Emergency Parachute Recovery System (AEPRS): *"Now is the time, early in the vehicle development cycle will pay dividends in the future"* (NASA). The industry should expect that accidents will happen and put into place technology to protect the occupants to ensure continued growth and acceptance of AAM. The regulatory environment (DoD & FAA) gives attention to system level safety. ASR has been awarded two Agility Prime contracts (SBIR/STTR) for AEPRS system development.

Technology works: AEPRS is specifically designed for VTOL recovery within 100-ft. AAM success will be dependent on safety: AAM will have to demonstrate high safety levels expected by the public.

Agility Prime with an initiative to accelerate the growth of the vertical flight market, industry and military officials want to lay the groundwork for eventual civilian certification of AAM technology, as well as the approval of autonomous inter and intracity flights.

USAF approval of current AAM vehicles on the market will also enable the acceleration for the aircraft's safety analyses via conducted flight tests to verify vehicle reliability and generally vetting the capabilities of vehicles.

There may be considerations from the USAF and other regulatory agencies to support installation of an AEPRS. Design work early, versus in a retrofit or aftermarket environment, is much more efficient and cost effective.

Product: The problem with conventional parachutes is that it takes time to inflate them. They need enough altitude and airspeed to serve their purpose. Even the use of rockets to quickly extract a single canopy won't inflate it in time if low to the ground. If an aircraft is going 122 mph and falling at a rate of 179 ft/second, it takes 5.5 seconds to inflate the parachute canopy and produce a stable decent (<30-feet per second). ASR worked around this limitation with an innovative patented solution that takes half a second to extract three small canopies and only 2 seconds to inflate. ASR's recovery parachute works at 100 ft or less of altitude loss in 2.5 seconds even in a VTOL operation.

- Until the aircraft reaches a forward speed of 107.6 knots (123.82 mph), the canopy does not have time to inflate and slow the vehicle decent (the altitude loss is 290 feet)
- Speed at impact without a parachute:

    - >15-ft injurious (1,500 lbs. spinal loading) = 31.04 f/s (21.17 MPH) in .97 seconds
    - >100-ft fatal = 80.18 f/s (54.67 MPH) in 2.49 seconds
- The ASR eXtreme Rapid Deployment (XRD) solution is the "airbag" for Advanced Air Mobility – cannot completely eliminate the risk, but ***may prevent the fatality***
- Other conventional recovery systems are credited for 453 lives saved lives (as of 13 May 2021, on the Cirrus Aircraft SR-series, the CAPS had been activated 123 times, 104 of which saw successful parachute deployment) – One system in every 110 aircraft produced have been deployed. Cirrus parachute (64-ft canopy) takes 920 ft. of altitude loss to inflate (from a flat spin):
    - 920-ft = 243.24 f/s (307.14 MPH) in 7.56 seconds
    - BRS holds an STC for the Cessna 172 and 182 models – available as an aftermarket install
- ASR products are ~20% lighter, ~10% lower cost, 12-year repack cycle vs. 6-year with BRS/Cirrus parachute systems
- The weight of the ASR parachute for a 4,500 lb. aircraft is ~100 lbs., which begs OEMs and operators to consider a 100 lb. weight penalty could save 6 lives.

Market: The University of Michigan's Sustainable Worldwide Transportation Program conducted a nationwide survey and reports that 63% of respondents say they are "very concerned" about the safety of Flying Cars (AAM/UAM) vehicles and 80% said a parachute would be "very" or "extremely" important. (https://www.latimes.com/business/autos/la-fi-hy-flying-cars-survey-20170418-story.html)

- There is also a positive marketing aspect to the notion of a recovery system such as a parachute. Public perception is ready for parachutes. A September 17, 2020 poll by AvWeb.com showed that of the 7,419 respondents, 4,326 (59%) indicated they either, (1) *"Yes, already have one"*, or (2) *"Yes, I'd like the option if available"*. Only 19% responded, *"No, I don't like the idea."*
- From October of 2020 to October 2021, there is over 5000 orders for manned aircraft mounted systems and over 12000 orders for unmanned aircraft mounted systems from more than 700 GA/LSA/AAM/UAM/UAS/Drone manufacturers to the various OEM parachute manufacturers in the U.S. This equates to nearly 3 billion dollars in parachute systems just in the civilian market alone.

Accident Data: Technology works – by 2016 there has been a 57% decrease in the GA accident rate:

- 0.93 fatalities per 100,000 flight hours – a 61% reduction over 2001-2005
    - Significantly impacted by Cirrus (CAPS) – deployments <200 kts and >300 ft = 0 fatalities
    - Of a reported 84 CAPS saves there were only 10 serious injuries and 19 minor injuries

Should You or Shouldn't You?

Here are the things you should think about when making the decision to buy and install a whole aircraft parachute system in your experimental aircraft project.

In that moment when you pull an emergency handle, you give up every semblance of control of your aircraft, and you are now along for the ride, whatever it brings. You've made the decision that your life can be saved, knowing that the aircraft surely will be damaged in the process. If the system deploys successfully, it will lower you and your aircraft at the rate of about 1600 feet per minute, or about 27 feet per second. This is around 18 miles per hour, so the engineering for attitude of the aircraft and the crushability and protection of structure under you is vitally important.

Myths vs Facts:

"A skilled pilot does not need a parachute in an emergency." This is 90% myth. Encountered with a serious structural failure, such as the loss of a wing, even the best trained pilot is going to have difficulty saving the airplane. The part that's 10% true has to do with the ability of a highly trained pilot to deal with emergencies. With non-structural failures and engine-outs, sometimes calm and competence can mean a very safe landing over areas where a landing is possible. But the fact is, skills deteriorate quickly in serious emergencies.

"Just take along your own parachute, it's cheaper and simpler." This also is 90% myth. Yes, it is cheaper, but unless you have the parachute fastened properly to your body, it will, unlike the James Bond tricks, be impossible to grab and don your parachute properly and exit the aircraft safely all at the same time in a crisis. The 10% true part? James Bond tricks—you never know.

"There is absolutely no downside to a whole aircraft recovery parachute. It will save you in all circumstances." At least 20% myth. A recovery system is absolutely a great addition to the aircraft. But gravity plus physics dictate that at very low altitudes, the deployment may not help much. Most airplane crashes occur during landing, takeoff, and low-level flight. A stall turning to final with a spin is a common and mostly fatal accident where having a whole aircraft parachute system may not save the occupants.

BRS Aerospace says any crash energy mitigation by deploying the parachute is good. I believe this, but there is only so much the system can do at very low altitudes. The discussion of risk gets complicated when you consider that a variety of things could go wrong with the system, such as inadvertent entanglement in the prop, being impaled by a tree on landing, etc. OK, let's not think about it.

So back to our original question: What are the things you should consider when making the choice to add or not add an emergency parachute system to your aircraft project?

Does your kit manufacturer and/or the plans for your craft include an emergency parachute option? If so, then the decision is more a monetary and personal one. The installation should go smoothly.

Installing a parachute system will add 20 to 100 pounds (system dependent) to your project. Do the calculations and decide if you can live with flying with reduced cargo and/or space. Extra weight will also drive up your fuel costs and may change some of the aircraft's flight characteristics.

Does having a parachutes system mean extra maintenance? Yes, but not as onerous as you might think. BRS Aerospace says that the only maintenance is repacking the parachute every six years and replacing the rocket. Magnum's(http://www.uflyit.com/; https://www.stratos07.cz/en) repack interval is five to six years, Galaxy Systems(https://www.galaxysky.cz/), is nine years, and Aviation Safety Resources (https://www.aviationsafetyresources.com/) is 12 years.

Are the continuous firing rocket parachutes, like the Galaxy, better than the ballistic parachutes (ASR, BRS, Magnum) that operate on an initial firing with the other companies? After reviewing the technologies, it is hard to compare them and say that one is better than the other. The reason for this is

that each design carries with it its own engineering and testing, and all systems have proven to be reliable in the field. Over time, there may be a more definitive answer. For now, my advice is to choose a system based on manufacturer stability, service availability, and suitability of the product to your specific application.

What if there are no provisions for an aircraft parachute system from the kit manufacturer or in the plans for your experimental or ultralight? This makes things more complicated, but don't dismiss out of hand if you're willing to spend the time and money to do the proper design work for an installation. This will represent a major change to design and construction, but it's not out of the question. You should begin with the designer of the aircraft, who can answer some of the most critical questions before you get deeply involved only to realize it won't work. If you are working on an original design, the parachute system should be entered into the engineering calculations and flight characteristics. You'll also want a consultation with the parachute system manufacturer, and you may need to design some extra structure under the occupant seats and/or into the seats for cushioning and crushability.

Whole aircraft parachute deployment is still very rare. Situations where their use is obvious, such as structural failures or an unrecoverable flat spin, are rare. We're taught to fly the aircraft all the way down and make the best of the situation, not pull an emergency handle. And there is still a stigma surrounding the installation of a whole airplane parachute. At a recent aviation event in, one aircraft expert smart aleck said, pointing at the obvious cannister on a Kolb aircraft, "Oh, you expect this airplane to break up in mid-flight?" As the OEM for the AEPRS, I could only shake my head.

Many of the arguments against installing an AEPRS revolve around two primary points:

1. <u>High levels of Reliability</u> – Commercial aviation is at a very high reliability level, but it took decades to achieve the current level (commonly 10^{-9} is referenced – or one failure in 1,000,000,000 flight hours). Many, especially in presentations, so called "experts" will mention that AAM needs to be <u>at least</u> as safe as commercial aviation. While this is an easy "primary" goal to recite, the facts can separate these lofty statements into data driven facts:
    a. The 10^{-9} number was established by the commercial aviation industry over <u>decades</u> and is based on the perception that the general flying public would accept one commercial fatal air carrier accident per year, but more than that would dampen air travel. The math was based on the number of flights and how many hours needed to be completed before a fatal accident. (NOTE: The following chart is a famous chart produced by Sikorsky to represent how reliability numbers translate.)

	Statistical Days Between Significant Failures	1 Failure Per 1,000 Flight Hours (10^{-3})	Best in Class Today: 1 Failure Per 1,000,000 Flight Hours (10^{-6})	1 Failure Per 1,000,000,000 Flight Hours (10^{-9})
Niche Market At Best	100 Aircraft 500 Flight Hours/Year	7.5 days	20 years	20,000 years
Evolutionary	1,000 Aircraft 1,000 Flight Hours/Year	9 hours	365 days	1,000 years
Revolutionary	50,000 Aircraft 3,000 Flight Hours/Year	3.5 minutes	2.5 days	6.7 years

b. Achieving this level of reliability is difficult. Using this logic, 10^{-6} may be acceptable in the early "evolutionary" stages of AAM. Consider that the automotive industry produces 100,000,000 cars per year. The highest level of production predicted for AAM currently falls around 20,000 vehicles per year. This is 0.02% of the automotive market. This matters because of the amount of investment necessary to achieve the results that took decades to achieve in commercial aviation.

c. Events where high reliability is the key "means of compliance", that alone may not help in cases such as:
   i. Mid-air collision - A mid-air collision could completely disable most aircraft systems.
   ii. Structural failure - A structural failure can result from many conditions: encountering severe turbulence, excess speed, exceeding design load factor or a degrading and/or defective aircraft structure.
   iii. Loss of control - Loss of control could result from a control system failure, wake turbulence, pilot disorientation.
   iv. Loss of power over hostile terrain
   v. Pilot incapacitation - If the pilot is incapacitated the passenger(s) may not have the training or skills to execute a safe landing
   vi. Depleted energy – conceivably if in a multi-rotor vehicle, you lose critical thrust on one rotor, the other motors will have to increase their energy consumption to compensate – this can cause rapid depletion of stored energy. Since 80% of the stored energy is used on takeoff and landing, depending on location and terrain, there may not be enough energy to execute a safe landing. Out of fuel, with landing areas within reach - If a landing area is available and the aircraft is controllable, the airplane should be flown to a normal landing. (NOTE: Some high-profile OEMs have openly stated, that even with multiple rotors with independent power, the lost of one rotor will cause an increase in energy to the remaining rotors to maintain safe flight. In one specific case, a vehicle with five rotors, if they lose just one rotor, the energy increase to the remaining four rotors can be as high as 50%. The key result here is having enough energy to transition to a safe touchdown condition.)

2. Weight/Cost and Mission Need – This is a matter of high value versus low risk. What are the benefit gains of installing an AEPRS versus the weight and cost of the system?
3. Public Perception and Acceptance - Billions have been invested in AAM. A significant negative event in the early stages of adoption could harm progress of the entire industry. This has happened before:
    a. Virgin Galactic's first SpaceShipTwo broke apart, killing the co-pilot and injuring the pilot, during an Oct. 31, 2014, test flight. NTSB investigators say co-pilot error was to blame. Commercial/private space tourism has not yet recovered or materialized.
    b. In March 2018, a 49-year-old woman was hit by a self-driving car as she wheeled a bicycle across the road in Tempe, Arizona. Investigators said the car's safety driver had been streaming an episode of the television show The Voice at the time. The accident was the first death on record involving a self-driving car and resulted in Uber ending its testing of the technology in Arizona.
    c. In a new Morgan Stanley report there is a chapter, *"It's All Been Done Before, Is It Any Different This Time?"* New York Airways operated helicopter connections to Wall Street, Midtown Manhattan, and nearby airports for 30-years. In 1977 a New York Airways helicopter accident at the top of the Pan Am Building (now the MetLife Building) in Midtown Manhattan completely decimated the industry. The airline was unable to recover from the heliport accident and filed for bankruptcy in 1977. In a 1964 New York Times article, "*They described elaborate tests and preparations made to ensure the safety of the proposed scheduled flights from the roof*." Sounds a lot like AAM today!
4. High Value Versus Low Risk – There is no question that the installation of any AEPRS has costs in terms of weight, volume, and dollars. ASR has worked diligently to reduce weight, reduce volume, and reduce cost – all the while designing a system to work in VTOL. The value versus the risk can be quantified by the high value of the AEPRS (if you need it, you better have it) versus the risk of having the system on board.
    a. Consider, as of 13 May 2021, on the Cirrus Aircraft SR-series, the AEPRS (CAPS) had been activated 123 times, 104 of which saw successful parachute deployment. In those successful deployments, there were 212 survivors and 1 fatality. **No fatalities** had occurred when the parachute was deployed within the certified speed and altitude parameters, and two anomalous unsuccessful deployments had occurred within those parameters. As of 18 December 2018, 19 of the aircraft involved in CAPS deployments had been repaired and put back into service.
    b. Nearly all the current 526 VTOL designs underway are full electric, hybrid or hydrogen powered. Consider the battery technology and the history. Tesla has had over 40+ battery fires on their vehicles. If such a fire occurred on an AAM, in-flight, what options would be available? What if the fire burned and/or damaged electrical circuits, wiring harnesses used to transmit signals to control surfaces, or just a complete loss of power? Distributed electric propulsion will not recover the vehicle, no matter how many rotors.